MONTHLY PROGRESS REPORT
MONTANA DOT "PERFORMANCE PREDICTION MODELS"
October 2005

To: **Susan Sillick, MDT; Jon Watson, MDT**
Contract No.: **MDT HWY-30604-DT**
Contractor: **Fugro Consultants LP**
Contract Period: **June 2001- May 2006**
Prepared By: **Jim Moulthrop, P.E., Project Manager**
Date Prepared: **November 8, 2005**

PROJECT OVERVIEW

The overall objective of this research is to develop a design process and performance/distress prediction models that will enable the Montana Department of Transportation (MDT) to use mechanistic-empirical principles for flexible pavement design. The project involves a comprehensive performance monitoring and laboratory-testing program and spans a period of five years.

The specific tasks identified in the work plan are:

PHASE I
- Task 1. Literature Review
- Task 2. Review of MDT Pavement-Related Data
- Task 3. Establish the Experimental Factorials
- Task 4. Develop Work Plan for Monitoring and Testing

PHASE II
- Task 5. Presentation of Work Plan to MDT
- Task 6. Implement Work Plan – Data Collection
- Task 7. Data Analyses and Calibration of Performance Prediction Models
- Task 8. Final Report and Presentation of Results

NOTE: New information for the current month is notated by double-lines to the left of text, tables, or figures.

PHASE I: CURRENT WORK ACTIVITIES AND COMPLETED TASKS

Task 1 – Literature Review

Completed: The literature review summarized the pavement performance models to be considered within this project and was submitted to MDT in October 2001.

Task 2 – Review of MDT Pavement-Related Data

Completed: A review of the available pavement-related data specific to the State of Montana was completed and included in the Task 3 "Experimental Factorial" and Task 4 "Sampling and Testing Plan" submitted to MDT in October 2001.

Completed: A one-time final update of the calibration/validation database was planned for end of the project. However, due to the limited funds remaining this final update will not be performed. The update will take place most likely when Montana DOT installs the database on their system.

Task 3 – Establish the Experimental Factorials

Completed: The "Minimum Data Elements" report and the "Experimental Factorial" were completed and submitted to MDT in October 2001. The factorial consists of 93 LTPP test sections of which 39 are in the State of Montana and the remaining 54 in neighboring States and Canada. In addition, 10 non-LTPP, supplemental sites were established and included in the factorial: Condon, Deerlodge / Beckhill, Silver City, Roundup, Lavina, Wolf Point, Ft. Belknap, Perma, Geyser, and Hammond.

Task 4 – Develop Work Plan for Monitoring and Testing

Completed: The Monitoring and Testing Work Plan was developed and provided to MDT in October 2001. The document contains the Materials Sampling Plan, the Initial Testing Plan to document the baseline condition of each test site, the Laboratory Testing Plan to define the material properties and layer thickness at each test site, and the Performance Monitoring Plan to document time series data within the 60-month contract period.

Performance Monitoring Plan

Completed: All performance-monitoring activities have been completed as illustrated in the following table (Table 1).

TABLE 1 Performance Monitoring Activities

Activity	Available	Planned
Distress Surveys	June 2002 June 2003 June 2005	None
FWD	August 2001 April 2002 April 2004 March 2005 May 2005	None
Profile	October 2001 August 2002 October 2003 August 2004	None

Although Fugro will not coordinate or perform future monitoring activities as part of the existing contract, it is important that MTDOT continues to monitor these sites and generate data for future model calibration activities. The suggested monitoring activities are:

- Distress Surveys: annually (during the summer) and before any rehabilitation/maintenance activity that will have an impact on the observed distress.

- FWD Testing: annually and before any rehabilitation/maintenance activity that will affect the deflection response of the pavement (mill, overlay, etc.).

- Profile Testing: annually and before any rehabilitation/maintenance activity that will affect the smoothness of the pavement surface.

FWD Comparison Study

A comparison study was performed on LTPP sections in Great Falls and Big Timber, Montana (May 6-May 19, 2004) in which MDT LTPP sections were tested in parallel with MDT's FWD equipment and LTPP's FWD equipment. The purpose of this comparison testing was to identify any bias that might exist between the FWDs used to measure deflection data on different test sections that will be used on this project. The hypothesis was that there is no bias between the two devices.

The comparisons in measured deflection and backcalculated moduli between the MDT and LTPP FWD equipment led to the following conclusions:

- In the great majority of the cases the LTPP equipment measured higher deflections compared to the MDT equipment for all sensors and all drop heights. The bias was higher for sensor 1 and decreased as the distance from the load (sensor 1) increased.

- In terms of backcalculated moduli values, a clear bias between the two pieces of equipment is observed only for the modulus of the asphalt concrete (surface) layer. For the base and subgrade layers, overall there is good agreement between the MDT and LTPP backcalculated values.

- The ratio E_{MDT}/E_{LTPP} for the asphalt concrete layer ranges from a value of 1.5 at 300,000 psi to 1.0 at 2,000,000 psi. A simple correlation was developed and is given in Equation 1:

$$E_{LTPP} = 0.1975 \cdot E_{MDT}^{1.1064} \quad (R^2 = 0.90) \tag{1}$$

- Further testing is not necessary.

Profile Comparison Study

A study similar to the FWD comparison was carried out in June 2005. LTPP sections in Montana were tested both with LTPP profile equipment and MTDOT equipment. The research team received the data from MDT this month.

Distress Surveys

The last distress survey was carried out in June 2005 and the results have been included in the July 2005 progress report.

Task 5 – Presentation of Work Plan to MDT

Completed: A PowerPoint Work Plan was presented to MDT by the project team in October 2001.

PHASE II: CURRENT WORK ACTIVITIES AND COMPLETED TASKS

Task 6 – Implement the Work Plan – Data Collection

LTTP Sites
There are 93 LTPP sites included in the experimental factorial. Of these, 39 are located in Montana and 54 in neighboring States and Canada. A set of queries was written that can be used at any time in the future to extract the data needed from the LTPP database to update the information in the calibration/validation database. The database is now complete and populated with LTPP data.

Non-LTPP Sites
The 10 non-LTPP sites are:

- Condon
- Deerlodge / Beckhill
- Silver City
- Roundup
- Lavina
- Wolf Point
- Ft. Belknap
- Perma
- Geyser
- Hammond

All testing related to the 10 sites is complete and the results have been presented in previous progress reports.

Superpave Sites

In addition to the 10 non-LTPP sites, two Superpave sites have been selected for inclusion in the testing/monitoring plan. These sites are Lothair and Baum Road. Samples of material from the two sites were received from MDT during 2003 consisting of cans of binder, bags of bulk mix, and buckets with unbound material. The materials have been stored off site in a temperature-controlled facility.

Binder testing results from Trumbull (Granite City, Illinois) for the three Superpave mixture tests were presented in the May 2004 monthly report. Results of resilient modulus tests for the unbound materials were included in the September 2004 monthly report. Note that HMA cores were not available to test for indirect resilient modulus, tensile strength, and creep. However, gradation, volumetric properties, and viscosity can be used to predict the stiffness of the HMA layer using the Witczak et al. Dynamic Modulus predictive equation.

Vaughn, a third Superpave site, was added to the factorial in April 2005. MDT approved funds for the additional testing activities. The testing of the asphalt concrete mixtures is completed and it includes:

- Aggregate Gradation
- Air Voids, Asphalt Content
- Indirect Tension (normal temperature and low temperature)
- Creep Compliance
- Resilient Modulus (indirect diametral)

The test results for the advanced asphalt materials testing were provided in the August 2005 Progress Report.

Partial results for the resilient modulus testing of the unbound Vaughn materials (base, subbase, and subgrade) have been included in the September 2005 report. Additional testing is underway.

Task 7 – Data Analyses and Calibration of Performance Prediction Models

Completed: The calibration technique (the specific steps required to determine calibration coefficients) was demonstrated to MDT utilizing models similar in nature to the NCHRP 1-37A *Mechanistic-Empirical (M-E) Pavement Design Guide* (initially titled *2002 Design Guide*) models. The project team made this presentation to the MDT in August 2003 along with a progress report, findings, and an illustration of the calibration exercise for the Silver City test section. A detailed discussion of the calibration algorithm accompanied by examples and step-by-step instructions will be included in a chapter of the Final Report.

During this reporting period, the team produced the final version of the Calibration/Validation database containing all the data generated in this study, and commenced the final calibration activities.

In August 2004, a project meeting update and status report was held at MDT's headquarters. An overview of the work completed to date and a presentation on the calibration process as well as the results obtained to date were presented. A demonstration of the new M-E Pavement Design Guide software was provided to identify the complexity, detail the inputs, and note some of the problems that may be encountered by MDT personnel using the software for selected pavement types.

An initial performance prediction exercise was performed for the 10 non-LTPP experimental sites. Material test data together with historical traffic and climatic data were used to predict the performance of these sites in terms of fatigue cracking and rutting in the asphalt concrete layer and rutting in the base and subgrade layers. Predicted distress was compared to results of the two distress surveys available for these sites (June 2002 and June 2003) and to the rutting measurements taken in October 2001. The results of this exercise were included in the July-September 2003 Quarterly Report.

A second performance prediction analysis, similar to the one performed on the non-LTPP sites, was started on the LTPP experimental sites. The availability of LTPP data was investigated in parallel with this study. While the performance predictions could be done either by spreadsheets or using the M-E Design Guide software, the solution by spreadsheets was used primarily because the Design Guide software was not available at that time. However, after a review and revision of the project budget during the month of April 2004, the study was

suspended. The team considered the performance predictions that will be performed using the M-E Design Guide software to be of greater importance, and the funds available will be allocated to this effort.

The review edition of the M-E Design Guide software was released by NCHRP in mid-July 2004. The research team used the software to begin the calibration analyses for the performance models included in the M-E Design Guide.

The project team will complete a simplified calibration exercise using the same distress prediction models, but in a more simplified manner so that MDT can use this information with their pavement management database. This activity will be demonstrated to MDT during the final meeting and will be included in the final report submitted for review.

Task 8 – Final Report and Presentation of Results
No activity.

PROBLEMS / RECOMMENDED SOLUTIONS

No problems were encountered during last month and none are anticipated next month.

NEXT MONTH'S WORK PLAN

The activities planned for next month are listed below:

- Coordinate with MDT personnel on an as-needed basis.
- Obtain data for the comparison study of the Profile equipment
- Finalize materials testing activities for Vaughn and work on final calibration of predictive models

---

FINANCIAL STATUS

The Financial Summary I table shows the estimated expenses incurred during the reporting period.

The Financial Summary II table provides the total project expenditures by the Montana and FHWA fiscal years in comparison to the allocated funds for each fiscal year.

The Financial Summary III-A chart illustrates total expenditures from inception of the project June 2000 through December 2003. The Financial Summary III-B chart reflects total project expenditures from January 2004 to the end of the project, May 2006.

cc: Jim Moulthrop, Fugro
Dragos Andrei, Fugro
Amber Yau, Fugro
Veena Prabhakar, Fugro
Harold Von Quintus, ERES/ARA
Jon Watson, MDT
Greg Zeihen, MDT
Dan Hill, MDT
Matthew Witczak, Consultant
Mark Hallenbeck, Consultant

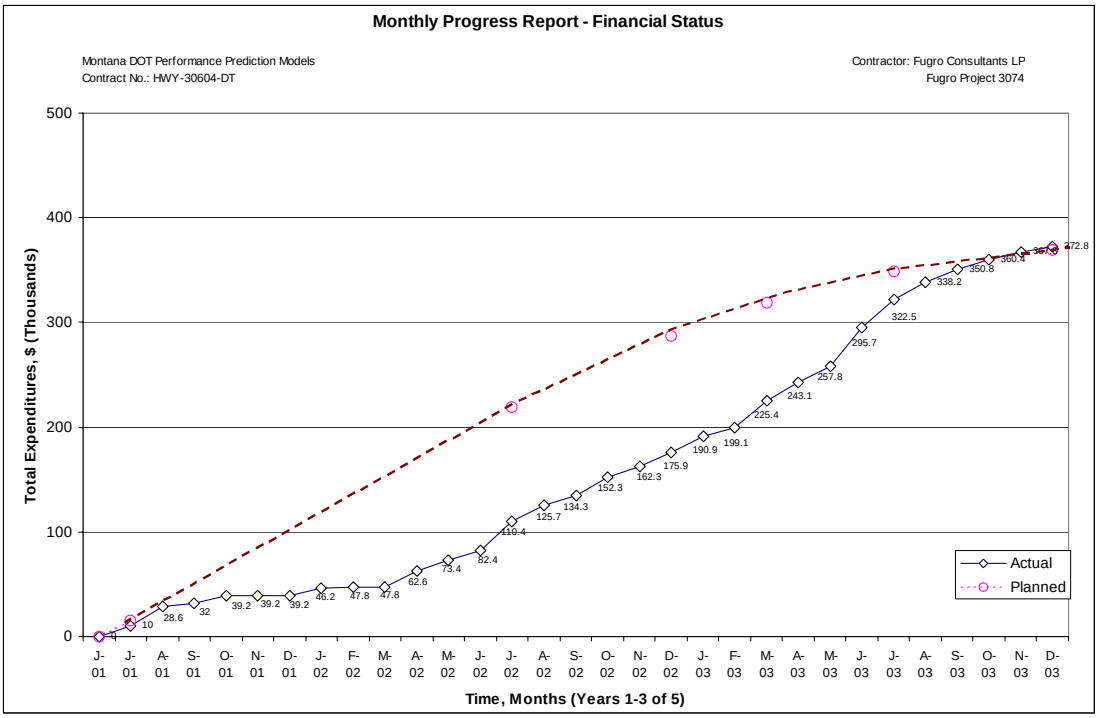
Financial Summary I
Estimated Expenses for Reporting Period: Fugro Consultants LP

Cost Element	Last Month Cumulative Project Costs, $	Current Month Expenditures, $	Total Cumulative Project Costs, $
Direct Labor	108,546	460	109,006
Overhead	155,221	657	155,878
Consultants/Subcontractors	68,951	-	68,951
ERES/ARA	39,857	-	39,857
Parsons-Brinckerhoff	12,093	-	12,093
SME	523	-	523
Matthew Witczak	2,850	-	2,850
Mark Hallenbeck	6,747	-	6,747
Brent Rauhut	1,200	-	1,200
Gianmarco Pendola	5,682	-	5,682
Travel	15,507	-	15,507
Testing	89,859	-	89,859
Other Direct Costs	7,073	-	7,073
Fee	41,858	-	41,858
TOTAL	487,016	1,117	488,133

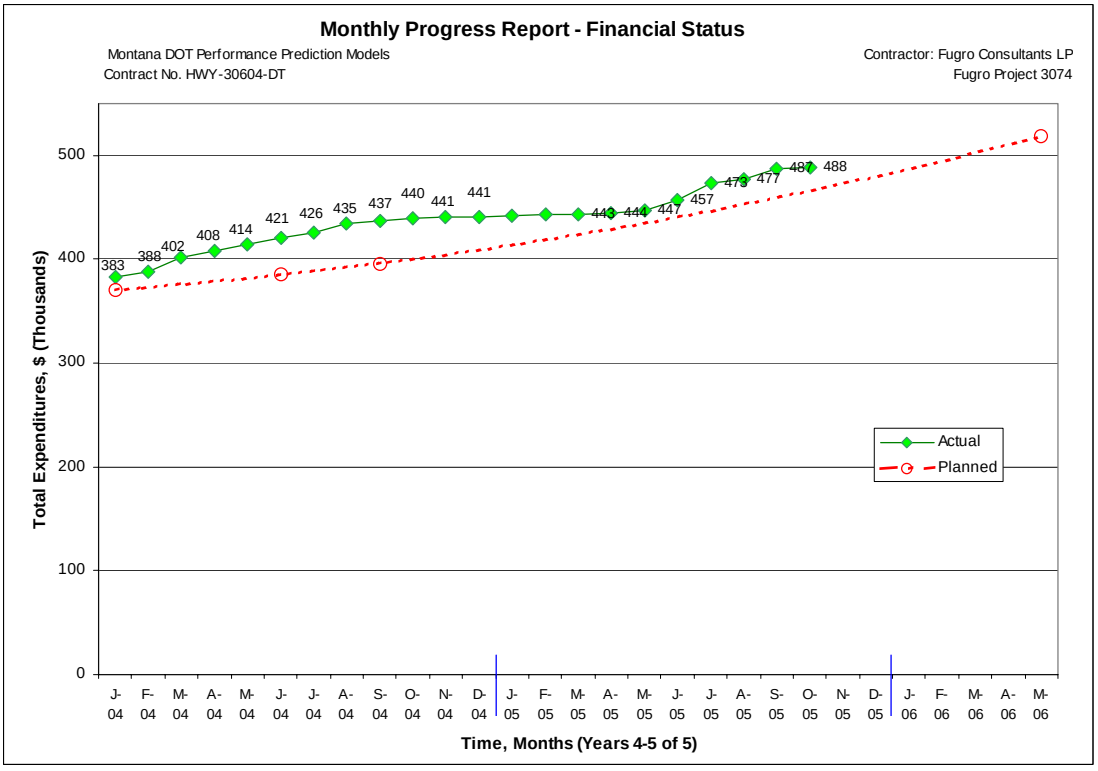
Financial Summary II
Total Expenditures by Fiscal Year: Montana and FHWA

MONTANA DOT FISCAL YEAR			FHWA FISCAL YEAR		
Fiscal Year	Total Cumulative Allocated Funds, $	Total Cumulative Expenditures, $	Fiscal Year	Total Cumulative Allocated Funds, $	Total Cumulative Expenditures, $
6/1/2000-6/30/2001	15,000	*0	6/1/2000-9/30/2001	65,000	31,996
7/1/2001-6/30/2002	218,969	82,420	10/1/2001-9/30/2002	258,969	102,303
7/1/2002-6/30/2003	348,969	213,291	10/1/2002-9/30/2003	358,969	216,187
7/1/2003-6/30/2004	388,969	125,486	10/1/2003-9/30/2004	398,969	86,695
7/1/2004-6/30/2005	428,969	35,918	10/1/2004-9/30/2005	438,969	49,835
7/1/2005-6/30/2006	517,561	31,018	10/1/2005-9/30/2006	517,561	1,117
TOTAL	517,561	488,133	TOTAL	517,561	488,133

*June 2001 expenditures were combined with July 2001 expenditures.



Financial Summary III-A: Total Expenditures by Month Jun 2000 – Dec 2003



Financial Summary III-B: Total Expenditures by Month Jan 2004 – Mar 2006